

Forward Auction and Incentive Auction Clearing Rule

All presented opinions are those of the design consultants and not necessarily the FCC

Forward Auction

2

- Given a certain amount of cleared spectrum, more is known about how to design licenses and sell them.
- We started with some baseline assumptions
 - ▣ Paired 2 x 5 MHz licenses (uplink + downlink)
 - ▣ Licenses defined for each Economic Area (176 in US)
 - ▣ Initial auction sells “generic” licenses in each EA.
 - ▣ Follow-up assignment round determines exact frequencies.

Forward Auction Design

3

- Prior FCC auctions have used the SMR format originally proposed by Milgrom-Wilson-McAfee.
- Some familiar issues
 - ▣ Near-equivalent licenses have different prices
 - ▣ Exercise of market power (unilateral and coordinated)
 - ▣ Exposure problems (if no package bids)
- Also, SMR auctions can take a long time
 - ▣ AWS auction (161 rounds), 700 MHz auction (268 rounds), Canadian AWS auction (331 rounds).
 - ▣ Time is a particular concern for incentive auctions.

Forward Clock Auction

4

- Seek a refinement that
 - ▣ Retains simplicity of SMR
 - ▣ Avoids “over-shooting” (like SMR)
 - ▣ Allows for generic licenses
 - ▣ Runs (a lot) faster
 - ▣ Plus ... accommodates variable supply, competition policy, possibly combination bidding, etc.
- Proposal: clock auction with *intra-round* bidding.

Proposed Clock Auction

5

- Assume K generic licenses in each geographic area (could be fewer in some “impaired areas”).
- Eligibility and activity rule
 - ▣ FCC assigns eligibility points to each product.
 - ▣ Bidders place deposits for initial eligibility, updated after each round to equal the minimum of prior eligibility and a multiple of prior round activity.
- Opening round
 - ▣ FCC announces starting price for each product.
 - ▣ Each bidder demands a quantity of each product that the bidder wants to purchase at the starting prices.

Intra-Round Bids

6

- At round t , FCC announces price interval $[p_{k,t-1}, P_{k,t}]$ for each product k . Price $p_{k,0}$ is the reserve price.
- A *price point* is a distance between the start of round and end of round price, e.g. 50.00% for product k is $\frac{1}{2} * (p_{k,t-1} + P_{k,t})$.
- A *bid* in round t is a list of price points and changes in demand (or *intra-round bids*), e.g.
 - ▣ At price point z , change demand by $(0, 0, \dots, -1, \dots, 0)$.
 - ▣ At price point z' , change demand by $(0, 0, \dots, -1, 1, \dots, 0)$.

Intra-Round Bid Processing

7

- An intra-round bid is *feasible* if
 - ▣ Total points post-change doesn't exceed eligibility.
 - ▣ Change that reduces demand for some product k does not leave aggregate demand for k below supply.
- Feasible bids are *prioritized* by price point (starting with 0.01%, 0.02%, etc.)
- Bid processing rule in a given round.
 - ▣ Assess feasibility of each intra-round bid.
 - ▣ Process feasible intra-round bid with highest priority
 - ▣ Repeat until no feasible intra-round bids remain.

Post-Round

8

- Price Posting for each product k
 - ▣ If k is in excess demand, $p_{k,t} = P_{k,t}$
 - ▣ If k isn't in excess demand and had a demand reduction in round t , $p_{k,t}$ is the highest price point at which there was an allowed demand decrease for k .
 - ▣ If k isn't in excess demand and didn't have a demand reduction in round t , $p_{k,t} = p_{k,t-1}$.
- Aggregate demands and price intervals $[p_{k,t}, P_{k,t+1}]$ announced. $P_{k,t+1}$ may depend on excess demand.
- If there's no excess demand, Closing Condition is tested. Auction may end or be extended.

Speed of Clock Auction vs SMR

9

- Two potential speed-ups
 - ▣ Prices rise together for identical products: in SMR with six equivalent licenses, and demand for seven, it takes six rounds to go up an increment. Here just one round.
 - ▣ Intra-round bidding can allow for larger increments.
- Some *preliminary* simulations by Larry Ausubel
 - ▣ Moving from SMR to Clock with fixed increments reduces number of rounds by 40%.
 - ▣ Doubling the increment size reduces round by another 40%, so 100 rounds could be reduced to 36.

Possible Extensions/Variations

10

- Alternatives to points-based activity rule
- Supplemental downlink (or TDD) can be sold too.
- Package bidding, e.g.
 - ▣ Self-imposed quantity minimums
 - ▣ Regional packages
- Industrial policy (e.g. set-asides, caps).

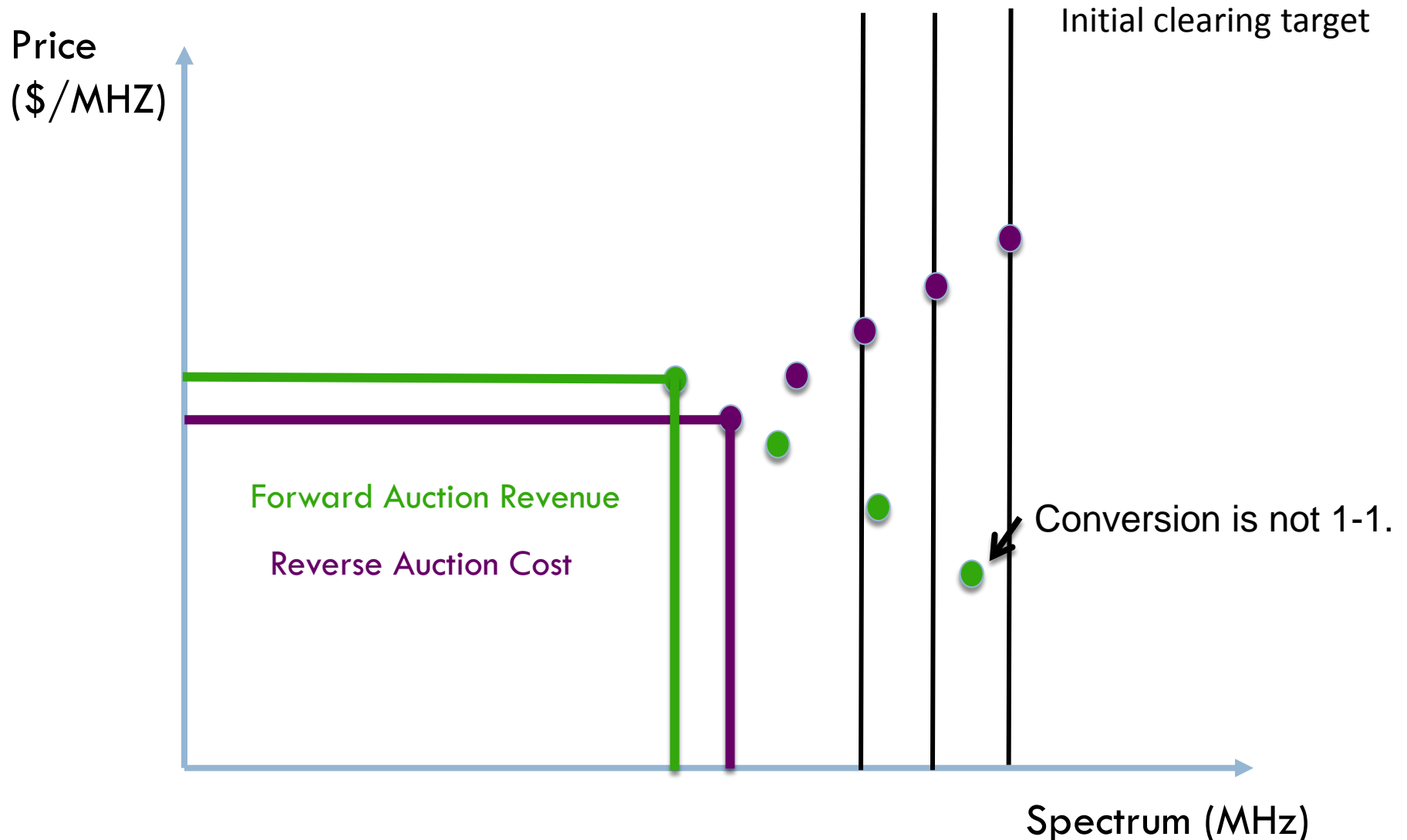


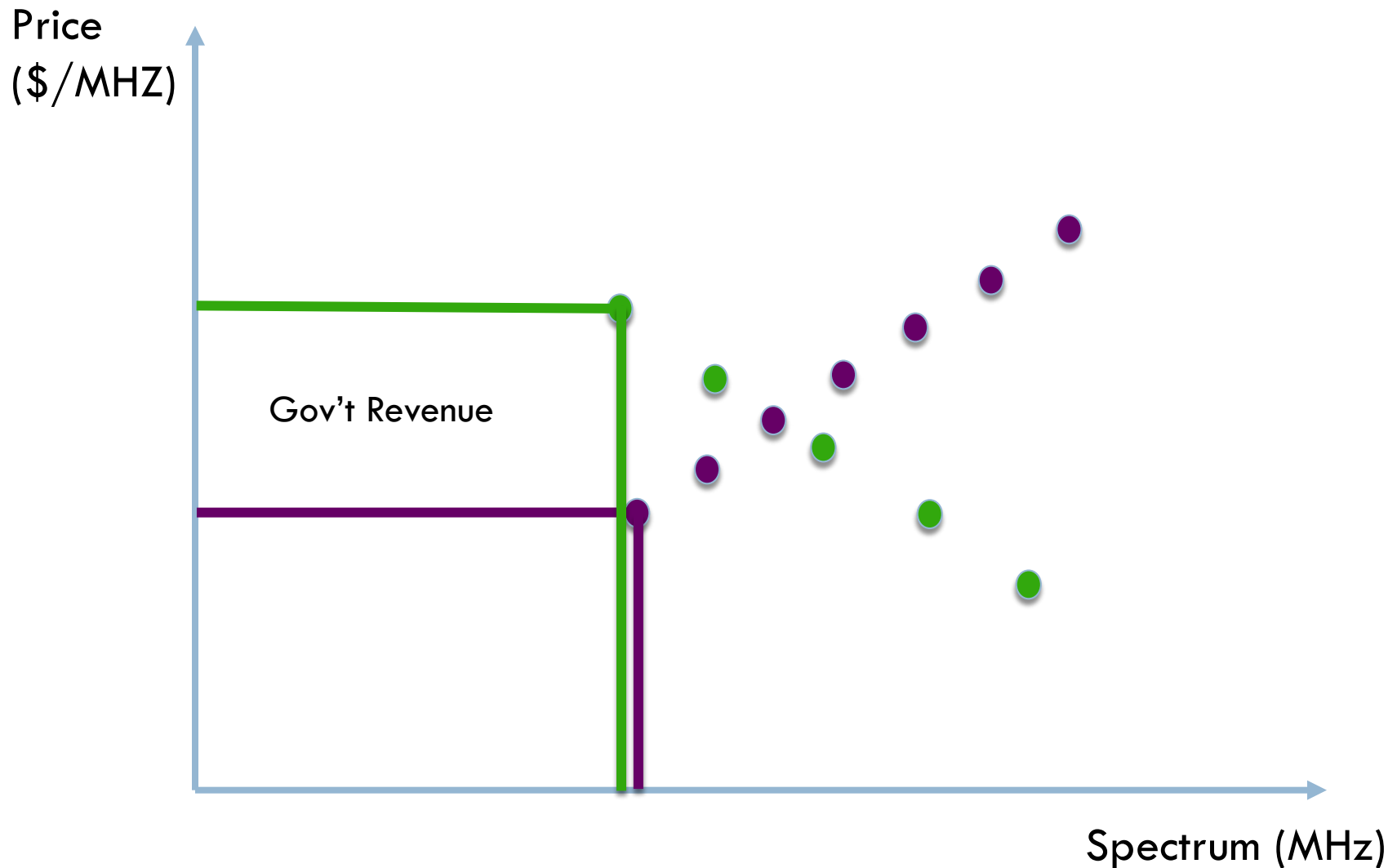
Connecting Forward/Reverse Auctions

11

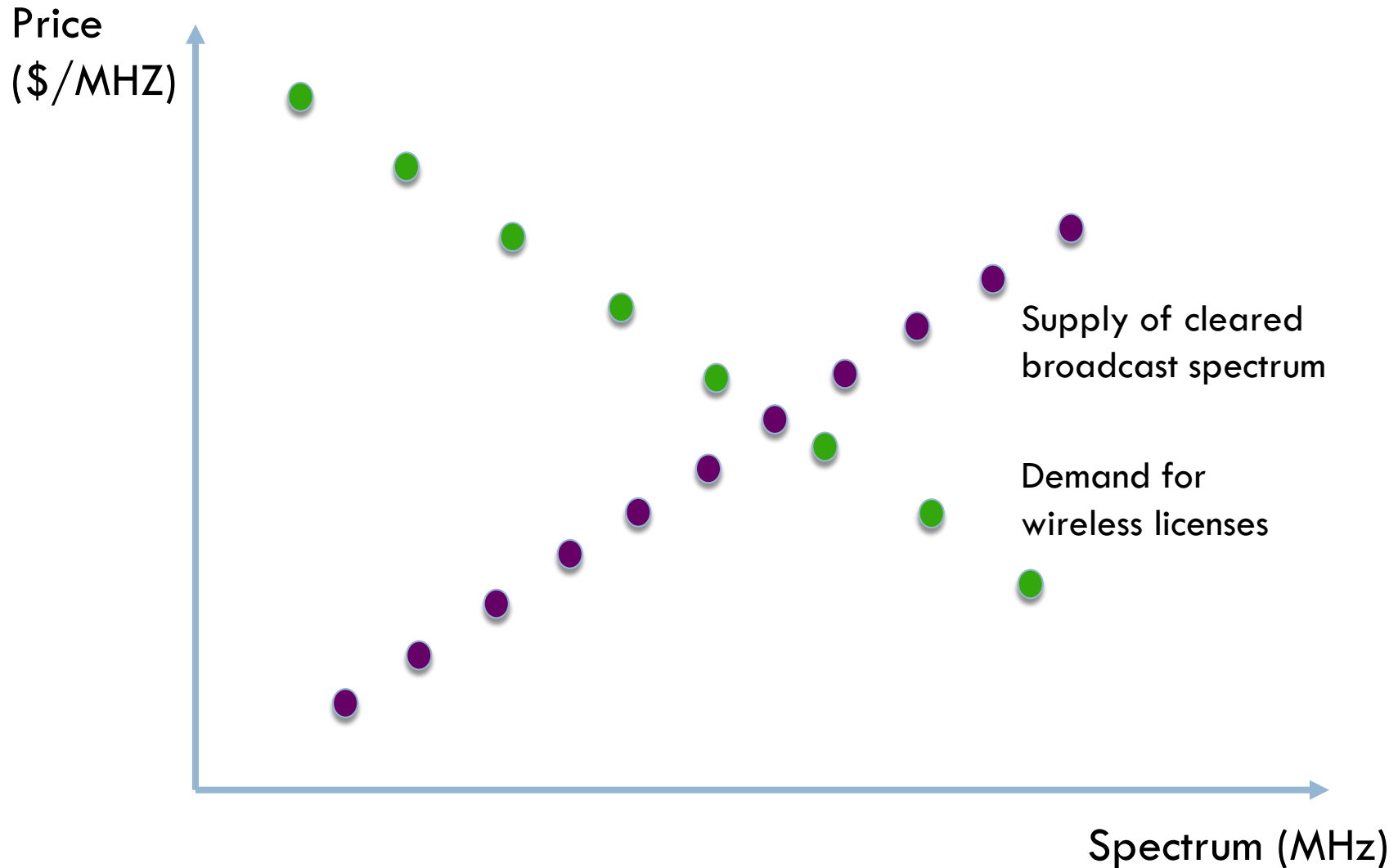
- NPRM Appendix assumed “national” clearing.
 - ▣ Auction would attempt to clear same number of channels nationwide (save for “impaired areas”).
- Some alternative auction timings
 - ▣ Sequential: Reverse auction first to elicit “supply curve” followed by forward auction to elicit “demand curve”.
 - ▣ Interleaved: Iterate between reverse and forward auctions with decreasing Clearing Target.
- Discuss interleaved approach here.

An Interleaved Auction





An Interleaved Auction



Closing and Clearing Rule

15

□ Closing Rule

- Specifies a “test” for when to terminate the auction, e.g. first point at which FCC revenue exceeds a target.

□ Clearing Rule

- After auction closes, potentially allow for “look-back” using a pre-specified rule, e.g. FCC would sacrifice $x\%$ of revenue to repurpose $y\%$ more spectrum.

- Details were left open in our NPRM Appendix.

“Extended” Rounds

16

- Simplest design finds, for a given Clearing Target,
 - ▣ Lowest clearing price in the forward auction
 - ▣ Highest clearing price in the reverse auction
- “Extended” rounds in forward auction
 - ▣ Reduce supply of licenses, and continue clock auction.
 - ▣ But keep testing Closing Rule against prior Target.
- Alternatives also possible, e.g. with sealed bidding and/or no substitution, or in reverse auction.

How Much Spectrum Can be Cleared?

17

- Comments suggest 50-60 MHz of paired spectrum
 - ▣ Depending on guard bands, use of duplex gap, “integer” issues, might equate to 72-84 MHz cleared.
- What (less obvious) factors might affect this
 - ▣ Imperfect conversion.
 - ▣ Local issues – e.g. some areas hard to clear.
 - ▣ The “white space multiplier”

Rough Calculation of Multiplier

18

- UHF stations cover 3,473,125,524 pops using 37 channels.
 - ▣ Packing efficiency is $3,473 / (37 * 313) = 0.30$
- For every 100 wireless pops created, 30 broadcast pops lost.
 - ▣ Imperfect conversion might reduce the 100 to 60-80.
 - ▣ But post-auction packing could reduce the 30 to, say, 25.
- Suggests a possible multiplier of 2.5-3: i.e. for every 1¢ per MHz-pop forward revenue that flows to broadcasters, they might receive on the order of 2.5¢ - 3¢ per MHz-pop.
 - ▣ NB: This is an illustrative calculation, *not a forecast!*

Assignment Round

19

- Must balance several objectives
 - ▣ Assign winners contiguous spectrum within geographic areas.
 - ▣ Assign winners contiguous spectrum across geographic areas.
 - ▣ Allow winners to select their preferred frequencies.
- Different alternatives are possible.
 - ▣ Recent non-US auctions have allowed winners to bid for specific frequencies while guaranteeing within area contiguity.
 - ▣ Could allow bids for cross-area contiguity as well.
 - ▣ If bidding is used, Vickrey pricing might be attractive.